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Transient free convection flow with constant suction

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The problem of transient free convection flow near a vertical flat plate with constant suction applied perpendicular to the plate is analysed. The transient is induced by a step change in the wall temperature. The solutions for the temperature and the velocity have been obtained by using Laplace transforms. The skin friction at the wall has been evaluated for various tmes for different values of the suction on which the solution is seen to depend A steady fall in the skin-friction with increasing suction is noted.

The basic equations which describe the unsteady free convection flow of a viscous incompressible fluid past an infinite flat plate with constant suction in non-dimensional form as shown by Lal (1969) are

$$\frac{\partial u}{\partial t}+v_0\frac{\partial u}{\partial y}=T+\frac{\partial^2 u}{\partial y^2} \qquad \ldots \quad (1.1)$$

$$\frac{\partial T}{\partial t}+v_0\frac{\partial T}{\partial y}=\frac{\partial^2 T}{\partial y^2}\;. \qquad \ldots \quad (1\ 2)$$

where the Prandtl number σ is taken as unity.

Appropriate boundary and initial conditions on the velocity and temperature are

$$\left.\begin{array}{ll} u(y,t)=T(y,t)=0, & t\leqslant 0 \quad y\geqslant 0 \\ u(\infty,t)=T(\infty,t)=0, & t>0 \end{array}\right\} \qquad \ldots \quad (1.3)$$

$$\left.\begin{array}{ll} u(0,t)=0, & t>0 \\ T(0,t)=T_0, & t>0 \end{array}\right\} \qquad \ldots \quad (1.4)$$

Using Laplace transforms with respect to the time variant t and solving the resultant ordinary differential equations and inverting we obtain in terms of β

$$T=\frac{T_0}{2}\left[\,e^{-\beta y}\operatorname{erfc}\left(\frac{y}{2\sqrt{t}}-\frac{\beta\sqrt{t}}{2}\right)+\operatorname{erfc}\left(\frac{y}{2\sqrt{t}}+\frac{\beta\sqrt{t}}{2}\right)\right] \qquad \ldots \quad (1.5)$$

$$u=\frac{T_0 y}{2\beta}\left[\,e^{-\beta y}\operatorname{erfc}\left(\frac{y}{2\sqrt{t}}-\frac{\beta\sqrt{t}}{2}\right)-\operatorname{erfc}\left(\frac{y}{2\sqrt{t}}+\frac{\beta\sqrt{t}}{2}\right)\right]. \qquad \ldots \quad (1.6)$$

where $v_0=-\beta(\beta$ being positive) since v_0 corresponds to suction.

The non-dimensional skin-friction τ_0' is given by

$$\tau_0' = \frac{T_0}{\beta} \operatorname{erfc}\left(\frac{\beta\sqrt{t}}{2}\right). \quad \ldots \quad (1.7)$$

The calculated values of τ_0' for several values of β and increasing t are given in the table.

TABLE 1. Values of τ_0'/T_0

$\beta \backslash t$	0	0.04	0.09	0.25
0	0	0.11284	0.16926	0.28210
1	0	0.11246	0 16800	0.27633
2	0	0 11135	0.16432	0.26025

From the table it is evident that for a fixed time t, the skin friction τ_0' decreases with increasing suction.

REFERENCE

Lal K. 1969 *Indian J. Phys.* **43**, 528.